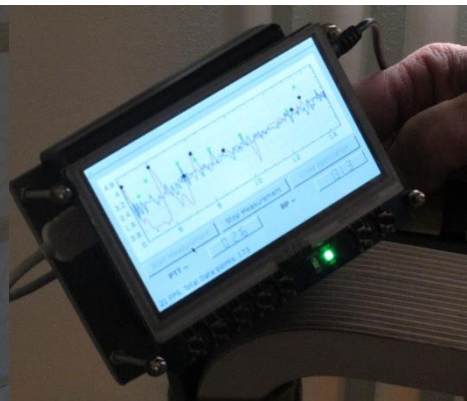
Chair for Building Realization and Robotics

Thomas Bock
Technische Universität München (TUM)







Outline

Automation, Robotics, Services (ARS)

Case Studies – Prefabrication

Case Studies – Single-Task Robots

Case Studies – Automated/Robotic On-Site Factories

Br2 projects in Horizon 2020

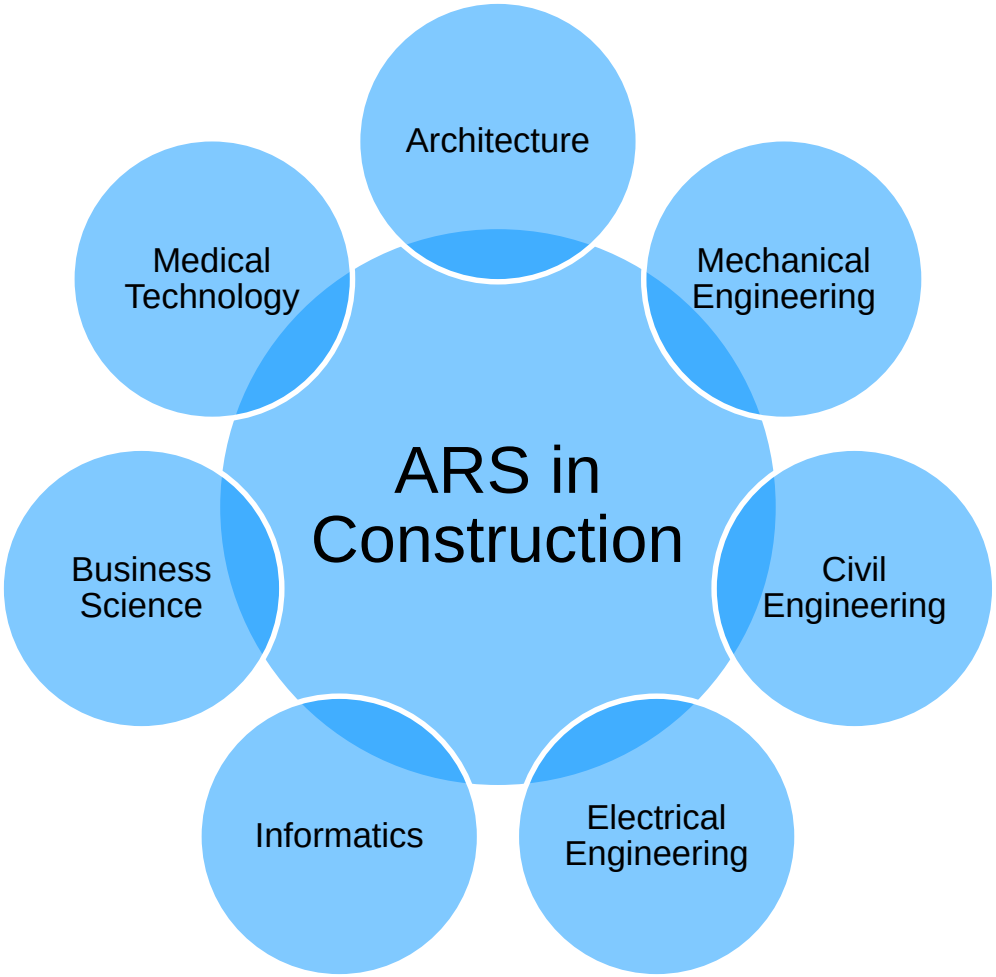
Sustainable Automation from an S-curve Perspective

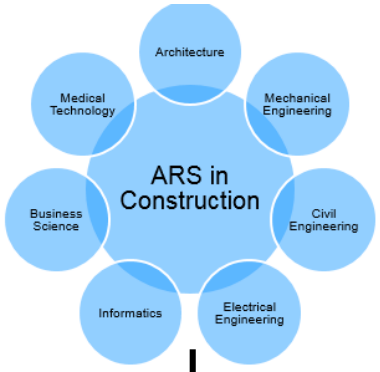
Outlook – Future Health Environments

References

AUTOMATION, ROBOTICS, SERVICES (ARS)

ARS requires a highly interdisciplinary approach…





Robot-Oriented Design

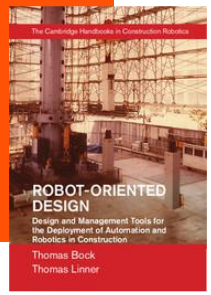
Prefabrication

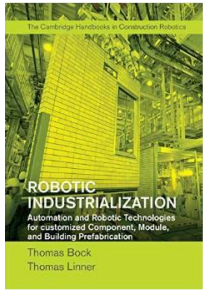
Construction robots

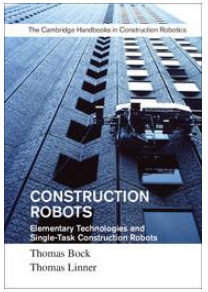
Automated Sites

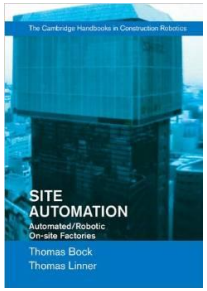
Robotic environments

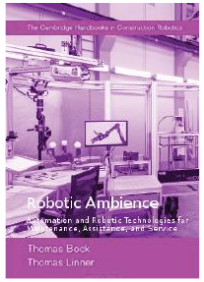
Module 1 | **Module 2** | **Module 3** | **Module 4** | **Module 5**

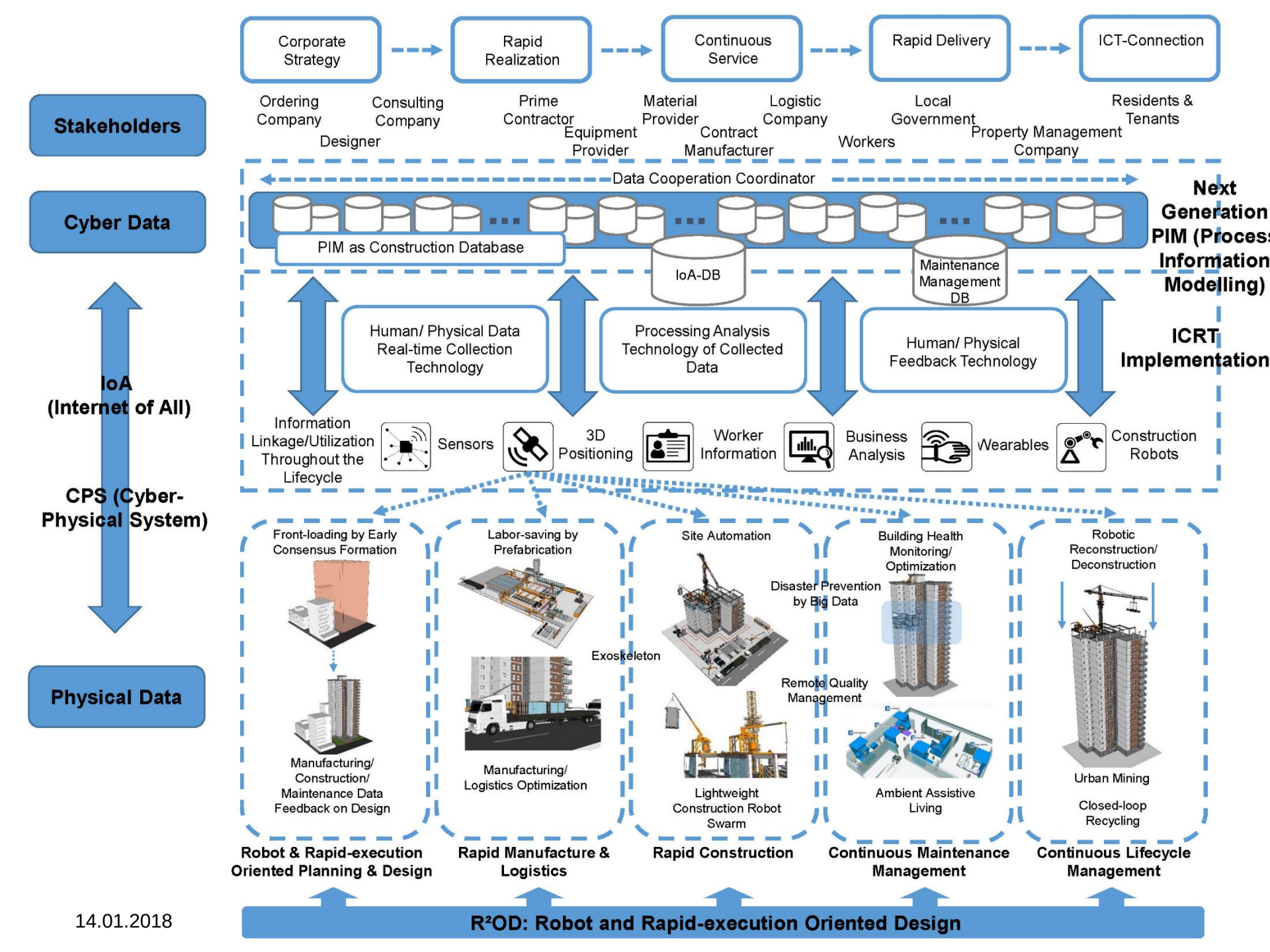


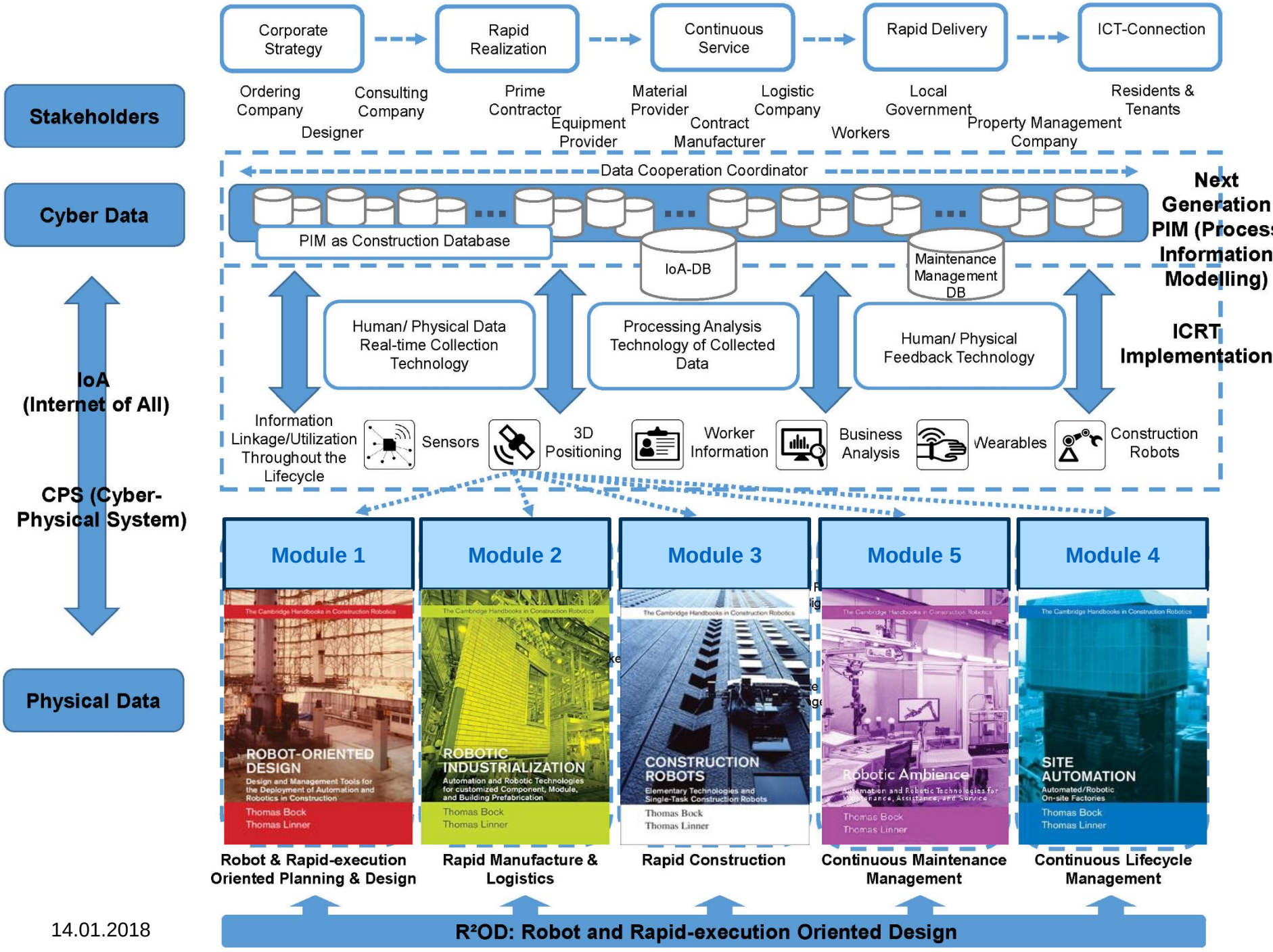









Corporate Strategy
Rapid Realization
Continuous Service
Rapid Delivery
ICT-Connection
Stakeholders
Ordering Company
Consulting Company
Designer
Prime Contractor
Equipment Provider
Material Provider
Contract Manufacturer
Logistic Company
Workers
Local Government
Property Management Company
Residents & Tenants
Data Cooperation Coordinator
Cyber Data
PIM as Construction Database
IoA-DB
Maintenance Management DB
Next Generation PIM (Process Information Modelling)
IoA (Internet of All)
Human/ Physical Data Real-time Collection Technology
Processing Analysis Technology of Collected Data
Human/ Physical Feedback Technology
ICRT Implementation
CPS (Cyber-Physical System)
Information Linkage/Utilization Throughout the Lifecycle
Sensors
3D Positioning
Worker Information
Business Analysis
Wearables
Construction Robots
Physical Data
Front-loading by Early Consensus Formation
Manufacturing/ Construction/ Maintenance Data Feedback on Design
Labor-saving by Prefabrication
Exoskeleton
Manufacturing/ Logistics Optimization
Site Automation
Lightweight Construction Robot Swarm
Building Health Monitoring/ Optimization
Disaster Prevention by Big Data
Remote Quality Management
Ambient Assistive Living
Robotic Reconstruction/ Deconstruction
Urban Mining
Closed-loop Recycling
Robot & Rapid-execution Oriented Planning & Design
Rapid Manufacture & Logistics
Rapid Construction
Continuous Maintenance Management
Continuous Lifecycle Management
R²OD: Robot and Rapid-execution Oriented Design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Module 1
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Module 3
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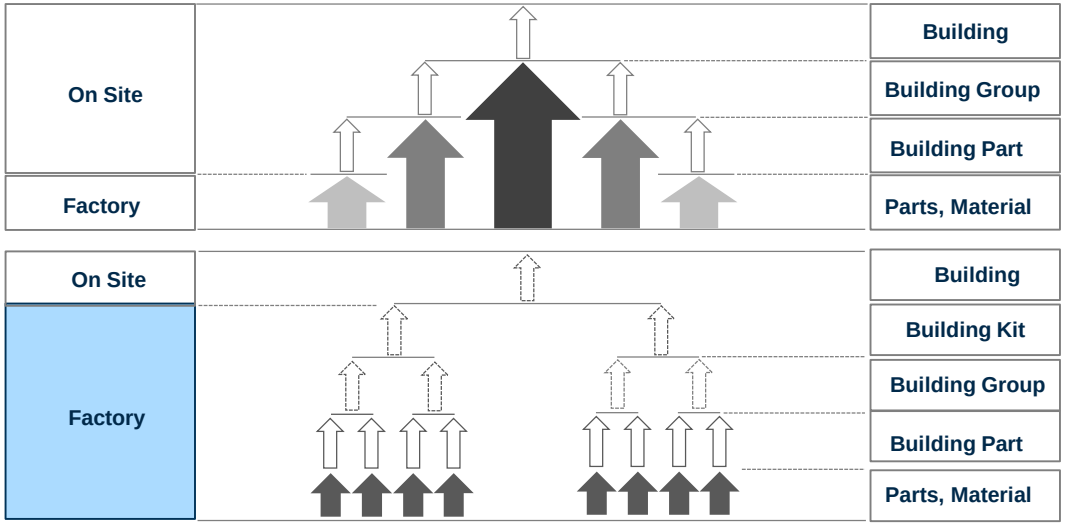
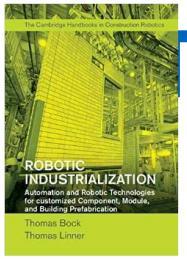
Module 4
ROBOT-ORIENTED DESIGN
ROBOTIC INDUSTRIALIZATION
CONSTRUCTION ROBOTS
Robotic Ambience
SITE AUTOMATION
Thomas Bock
Thomas Linner
Robot & Rapid-execution Oriented Planning & Design
Rapid Manufacture & Logistics
Rapid Construction
Continuous Maintenance Management
Continuous Lifecycle Management
R²OD: Robot and Rapid-execution Oriented Design

Module 1

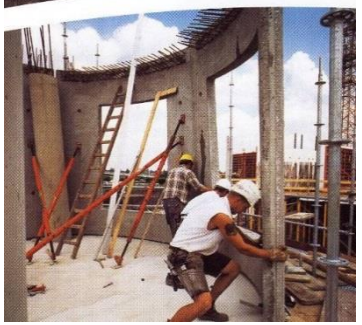
Adaptation of products, management, and processes towards robot utilization

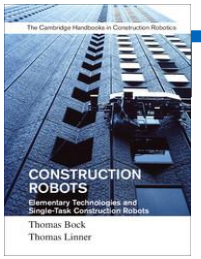




Module 2

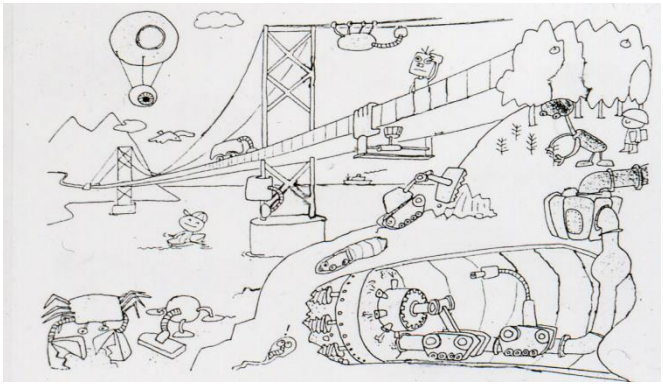
Customization and personalization through prefabrication of components

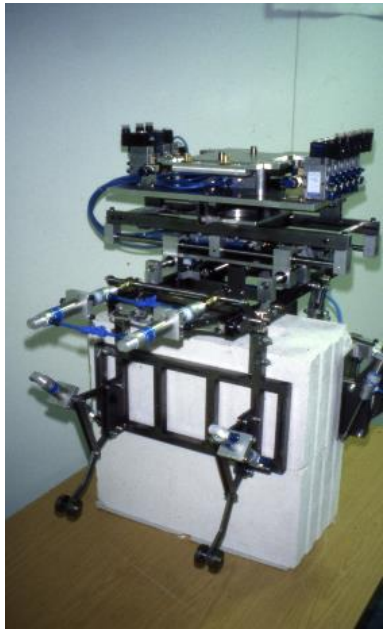


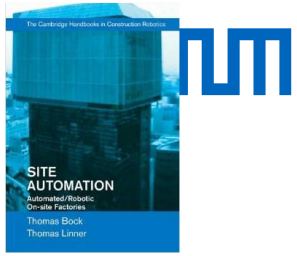


Module 3

Single-task construction robots

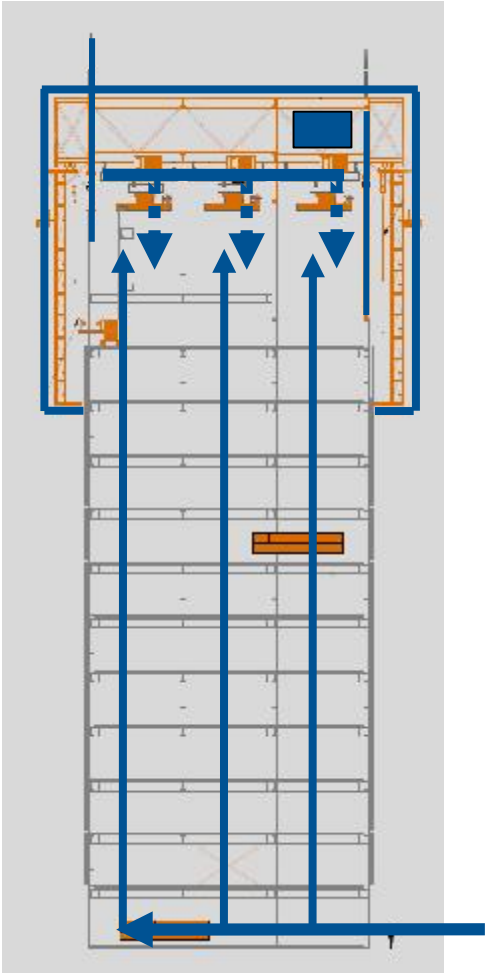


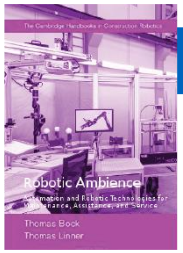




Module 4

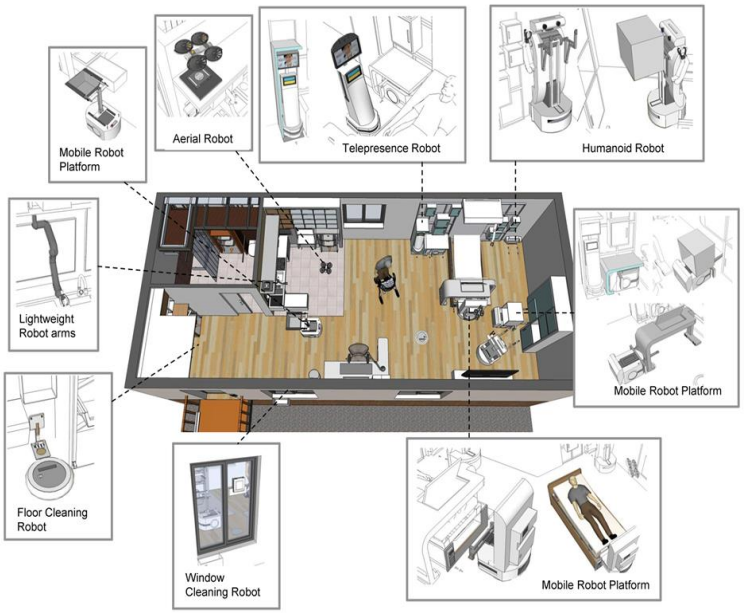
Integrated automated construction sites

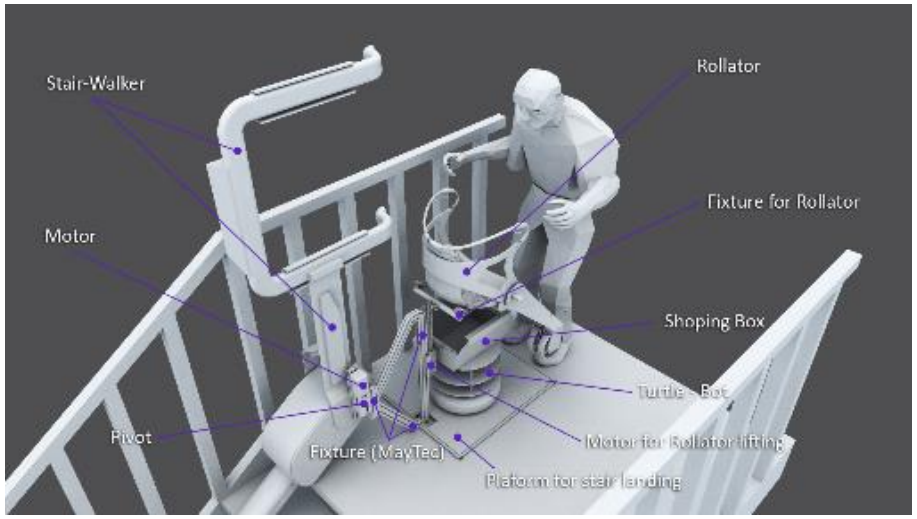


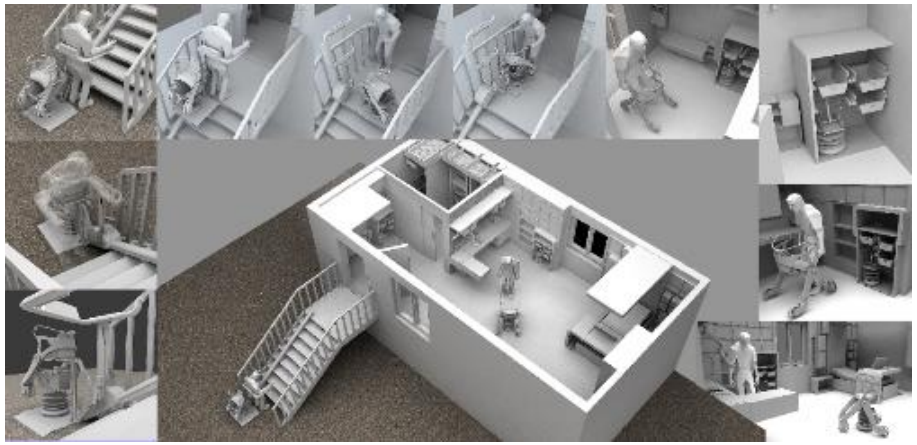


Module 5

Enhancement of the functionality of buildings through advanced technology







Case Studies – Prefabrication

Case Studies – Prefabrication

e.g. in tune with ISO 14001 certified environmental management systems

Prefab: Closed Loop Manufacturing and Re-Customisation

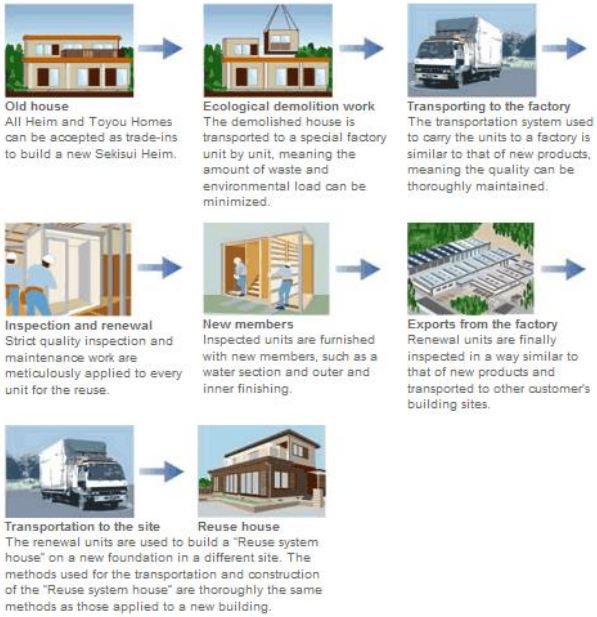
Sekisui Heim System Re-Use House

A new type of house, of which 70% can be reused

The waste emitted from the demolition of a single house is said to be 40 tons. If a house having completed its initial role becomes waste equivalent to the amounts carried by 10 trucks of 4 ton loading capacity, this cannot readily be accepted under current and future situations.

According to the concept of "reusing system houses", the familiar house, where you have long resided, does not become waste. Instead, 70%, excluding the foundations, will be reused for a new role, meaning that it minimizes environmental loads and also responds to the emotional attachment of the family having lived in the house.

Flow of the "Reuse system house"



Old house
All Heim and Toyou Homes can be accepted as trade-ins to build a new Sekisui Heim.

Ecological demolition work
The demolished house is transported to a special factory unit by unit, meaning the amount of waste and environmental load can be minimized.

Transporting to the factory
The transportation system used to carry the units to a factory is similar to that of new products, meaning the quality can be thoroughly maintained.

Inspection and renewal
Strict quality inspection and maintenance work are meticulously applied to every unit for the reuse.

New members
Inspected units are furnished with new members, such as a water section and outer and inner finishing.

Exports from the factory
Renewal units are finally inspected in a way similar to that of new products and transported to other customer's building sites.

Transportation to the site
The renewal units are used to build a "Reuse system house" on a new foundation in a different site. The methods used for the transportation and construction of the "Reuse system house" are thoroughly the same methods as those applied to a new building.

Reuse house

Case Studies – Single-Task Robots (for Renovation and Recycling)

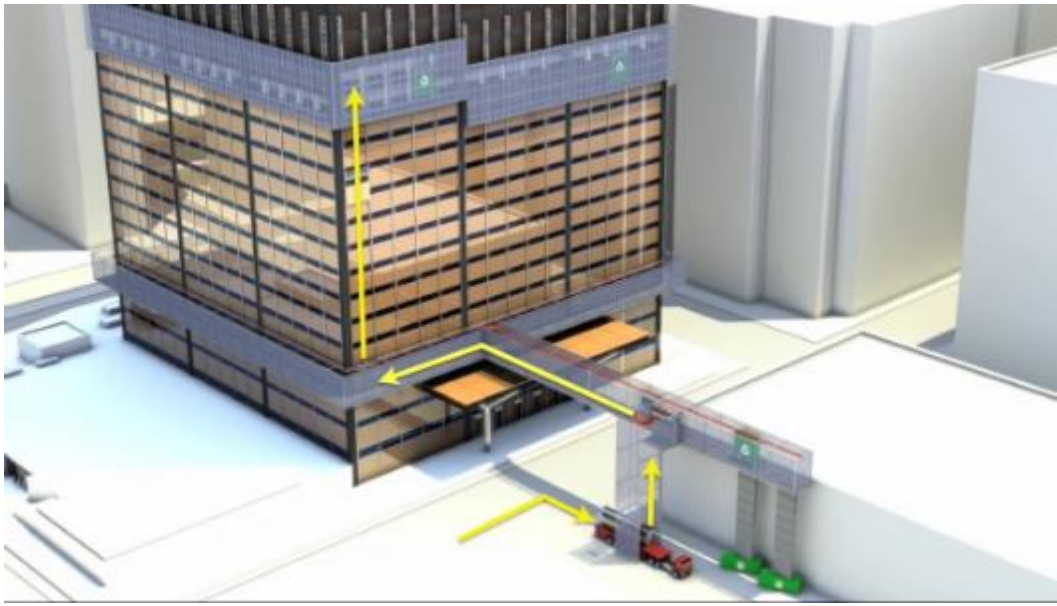
STCRs: Human-Machine-Collaboration

Image: Department of Robot Engineering, Hanyang University

SRL variant 1: prototype used in a drilling task (Image: © [2014] IEEE. Reprinted, with permission, from Parietti and Asada, 2014)

Vuzix M200AR waveguide HD device used by an electrician (Image: Vuzix Corporation)

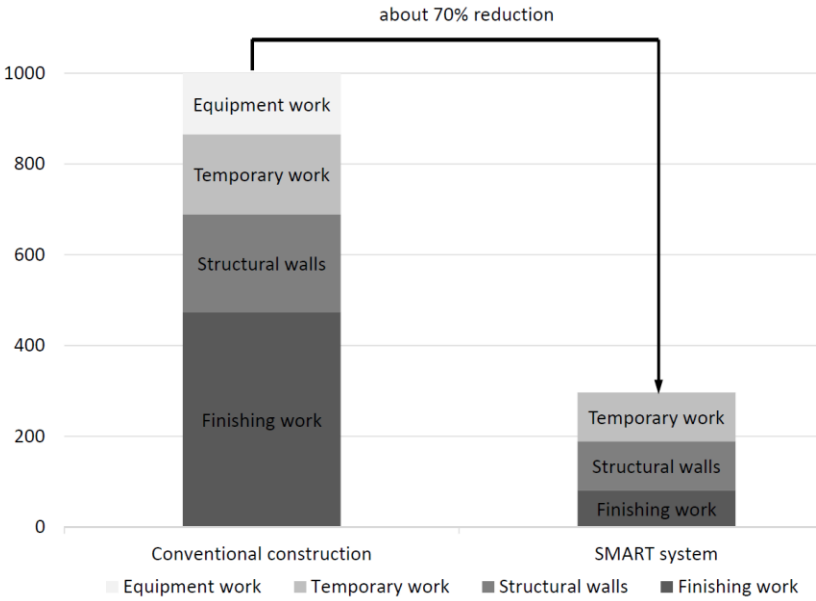
STCRs: Facade Renovation

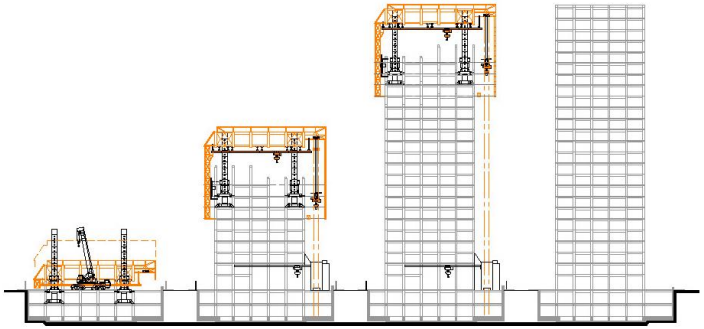


Brunkeberg® System - Outline of logistics and installation strategy
(visualisation; Image: Stefan Borell)

Case Studies – Automated/Robotic On-Site Factories

A/ROFs: optimized environmental management in construction

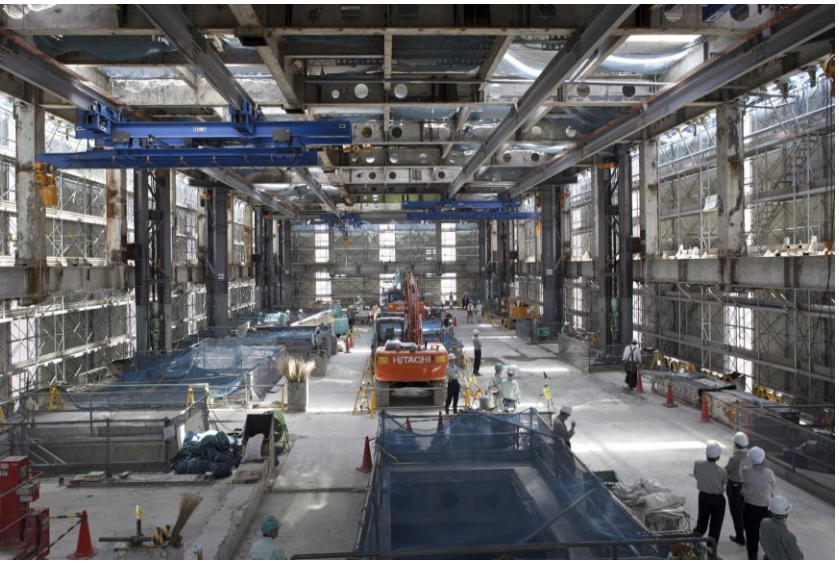


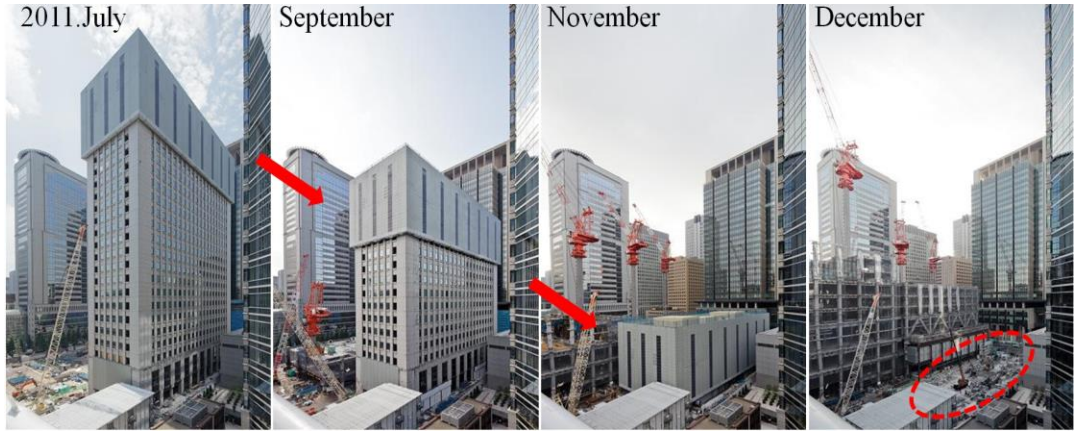


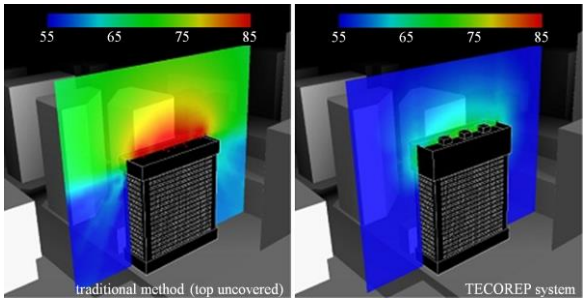
Reduction of construction waste realized through the application of SMART

(adopted from documentary material received from Prof. Maeda/Shimizu; see also Maeda, 1994; Maeda & Miyatake, 1997).

A/ROFs: optimized environmental management in de-construction/dis-assembly





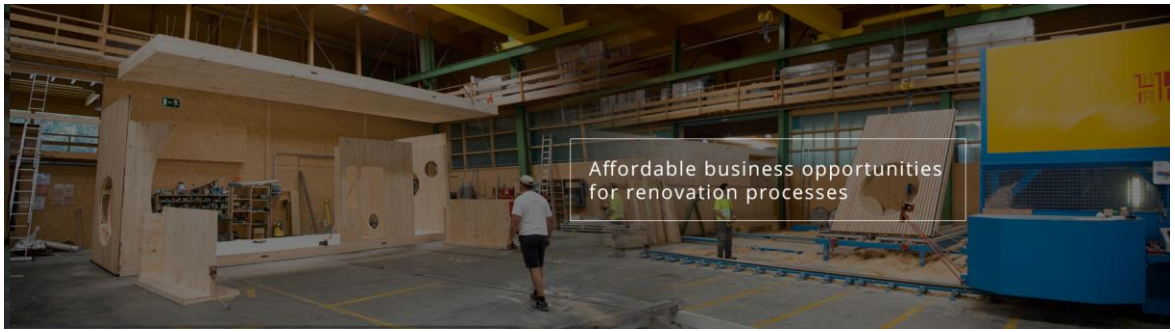


Taisei's TECOREP deconstruction system
Images: Taisei Corporation

Br2 projects in Horizon 2020

This project has received funding from the European Union's HORIZON 2020 research and innovation programme under Grant Agreement No. 636984

BERTIM (Building Energy Renovation through Timber Prefabricated Modules)



New prefabricated modules

Renovation process supporting tool (RenoBIM)

Innovative business models

Case studies

Research and Technology Institutes

tecnalia Inspiring Business

FCBA

Timber Prefab Module Manufacturers

martinsons

COLLAGE ARKITEKTER

Software Developers

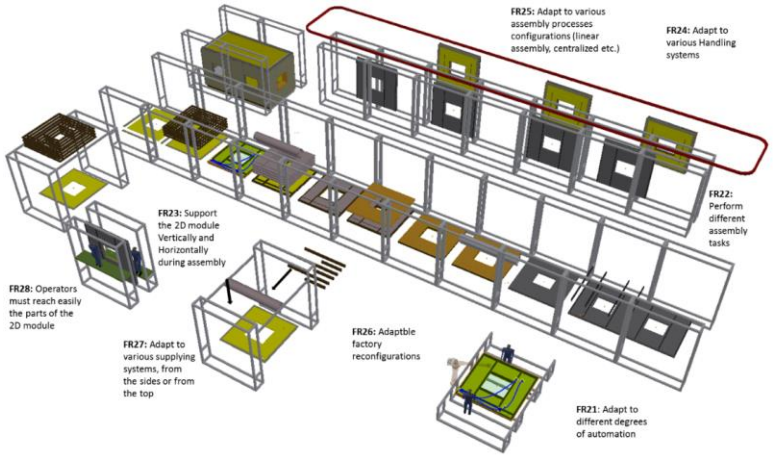
Dietrich's

MADRID emvs

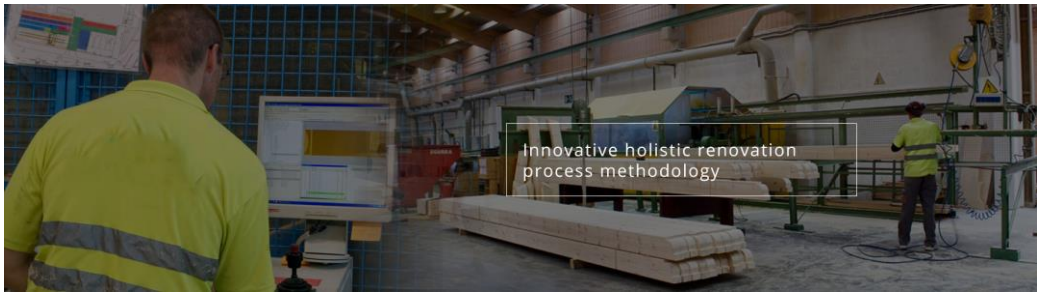
Market Research

This project has received funding from the European Union's HORIZON 2020 research and innovation programme under Grant Agreement No. 636984

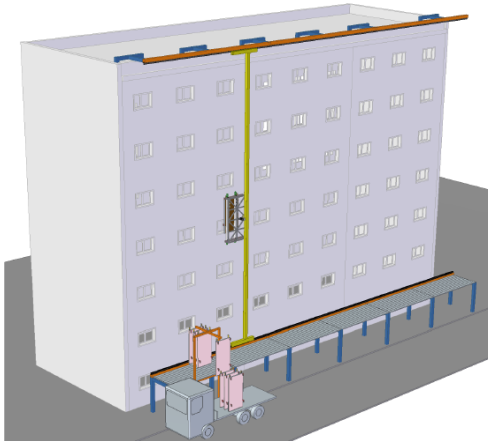
BERTIM

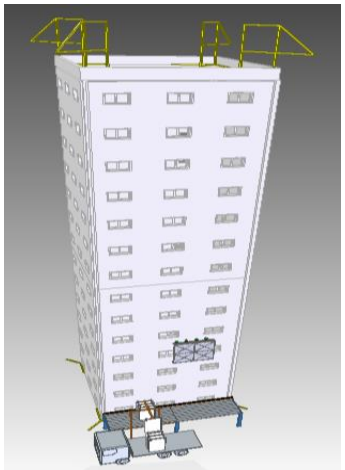


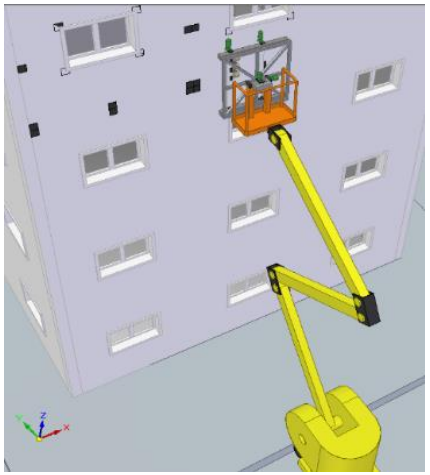
Maximize off-site manufacturing process of the modules within the existing facilities by a Modular assembly workstation kit



Minimize on-site Installation time and cost of the modules by a rapid installation system







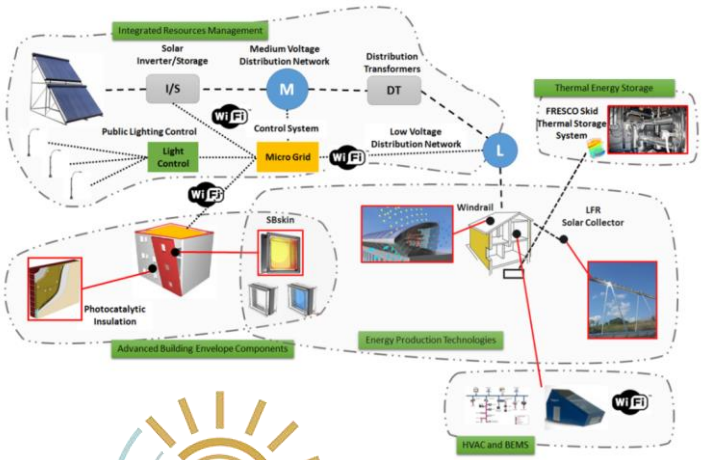
This project has received funding from the European Union's HORIZON 2020 research and innovation programme under Grant Agreement No. 678407

ZeroPlus (Achieving near Zero and Positive Energy Settlements in Europe using Advanced Energy Technology)

- **Objectives of the project**

Implementation of different technologies in order:

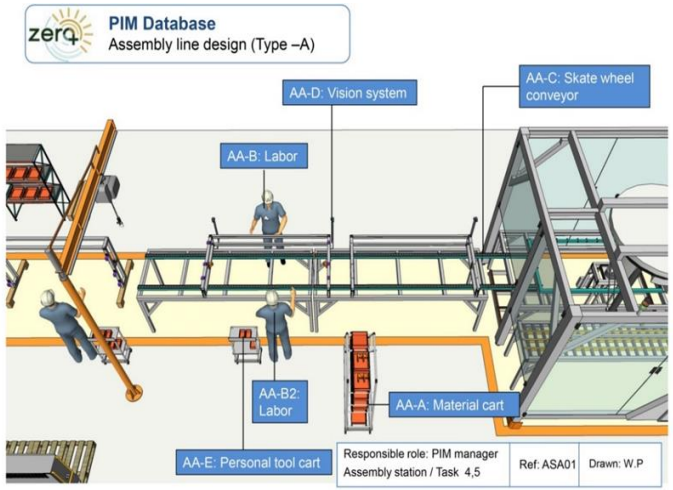
- to achieve a reduction of the operational energy usage in residential buildings to an average of 0-20 kWh/m²,
- to generate at least 50 kWh/m² of renewable energy per year, and
- to reduce by at least 16% of the NZE settlement costs, compared with current level.

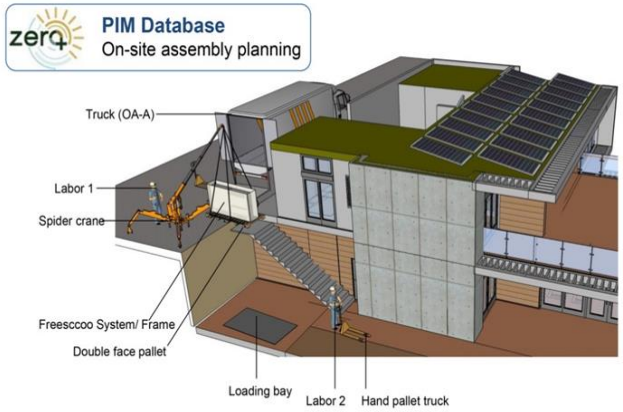


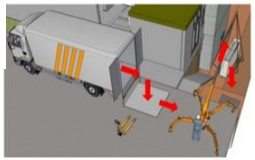
- **Partners:**
  - Universities:
  - Industry:
  - Case study owners:

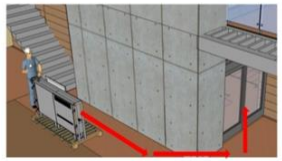
ZeroPlus

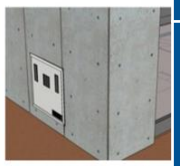
Demonstration of the integrated energy technology (Freescoo system & frame) using the example of Cyprus case study

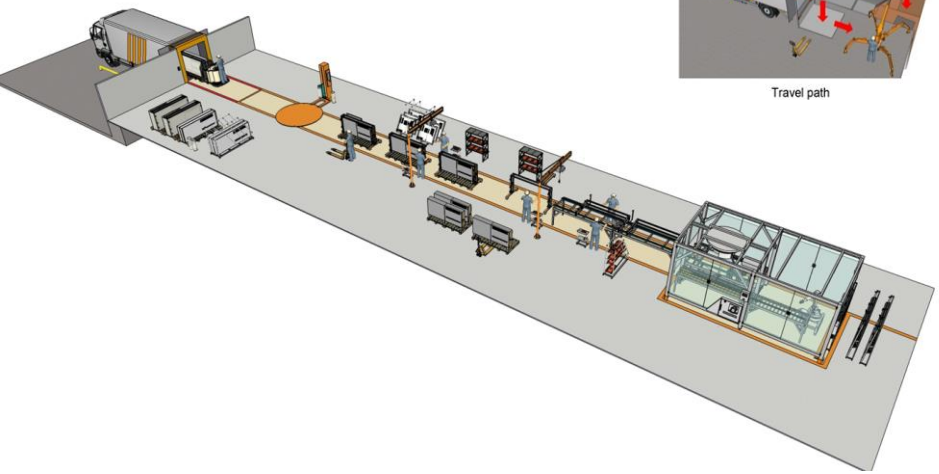


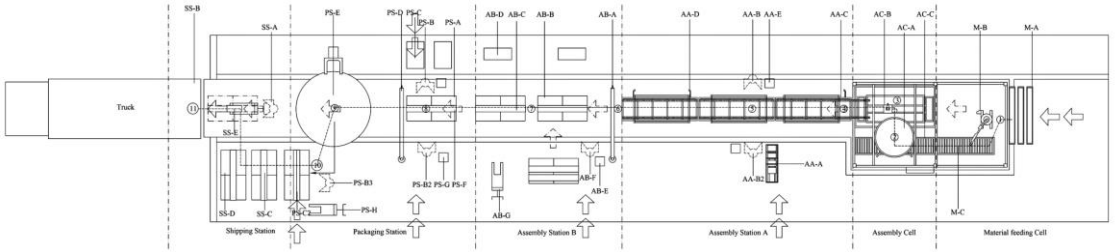



Travel path


Travel path


Assembly completed

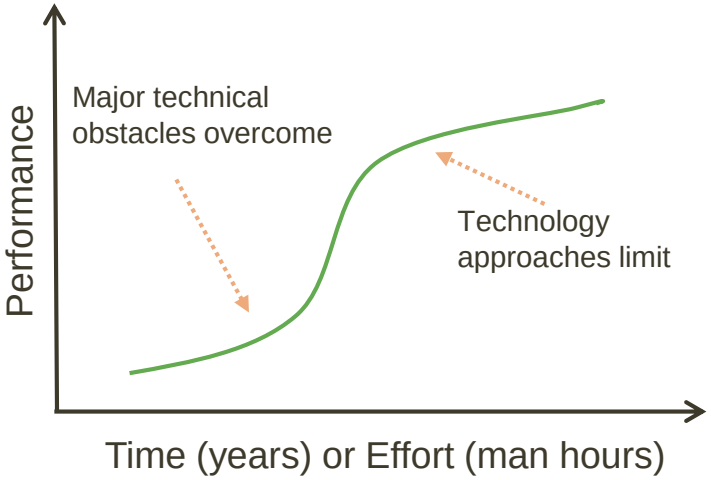


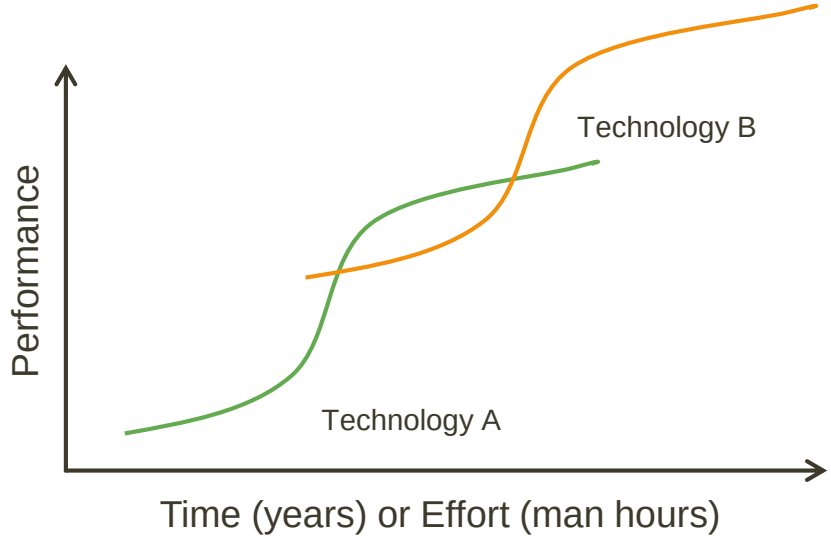


PIM Database	On-site Assembly Planning
Agent Class: MMH, AMH, ML, PT, LO **Task Identification: On-site assembly**	
OA-A	Truck Agent class: MMH (Manual Material Handling) Agent: OA-A Travel: Variable - path
OA-B/2	Human labour Agent class: ML (Worker) Agent: M-B Travel: Variable - path
OA-C	Spider crane Agent class: AMH (Automated Material Handling) Agent: OA-C Travel: Variable - path
OA-D	Freesccoo system/ frame Agent class: PT Agent: OA-D Travel: Variable - path
OA-E	Double face pallet Agent class: MMH (Manual Material Handling) Agent: OA-E Travel: Variable - path
OA-F	Loading bay Agent class: LO (Location) Agent: OA-F Travel: Fixed - path
OA-G	Hand pallet truck Agent class: MMH (Manual Material Handling) Agent: OA-G Travel: Variable - path

Sustainable Automation from an S-curve Perspective

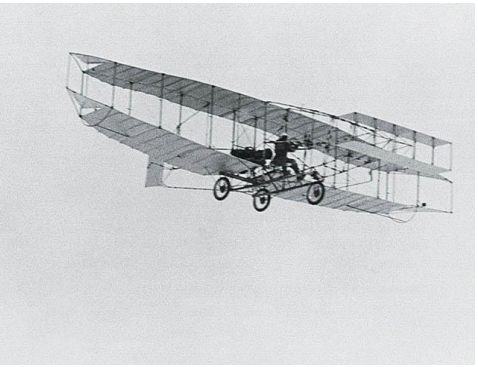
S-Curves





According to Foster (1986) an overlay of S-curves can be used to describe the relation between the stagnation and technical limits of one technology and the initiation, development and growth of new strategies and technologies.

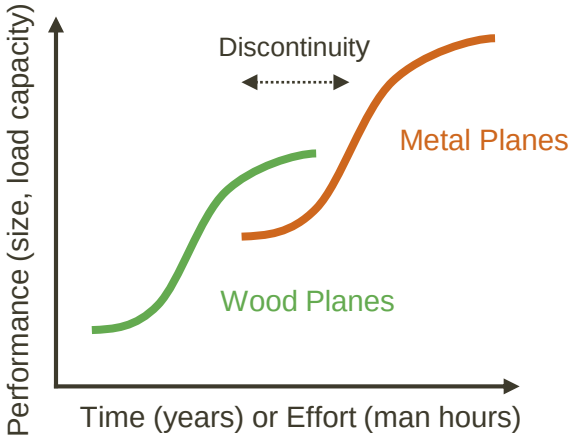
S-Curves Example



Double-decker

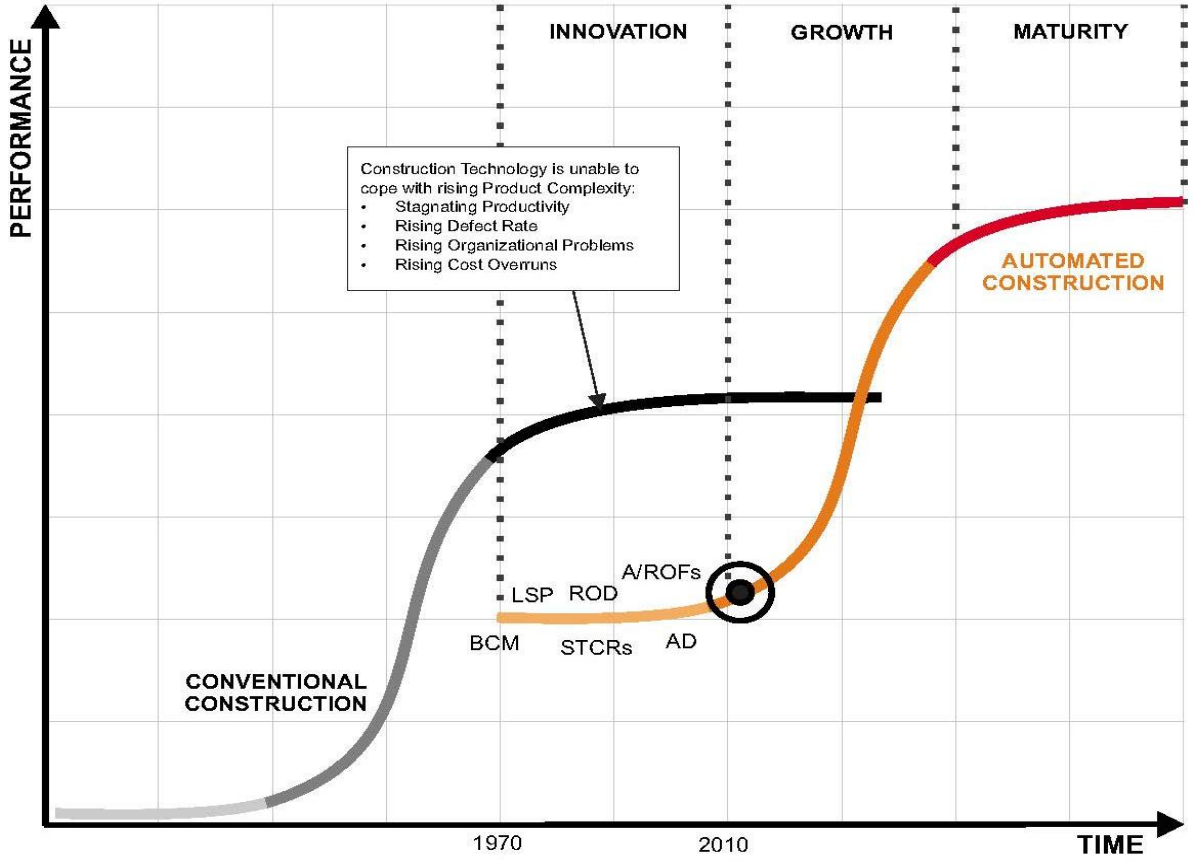
Drei-decker

Vier-decker



Full Metal Airplane Approach allowed for new S-Curve with higher limits

S-Curves and sustainable Automation



Outlook – Future Health Environments

GEWOS: Gesund Wohnen mit Stil

himolla
Polster für Menschen

Green. Smart. Wireless.
enocean

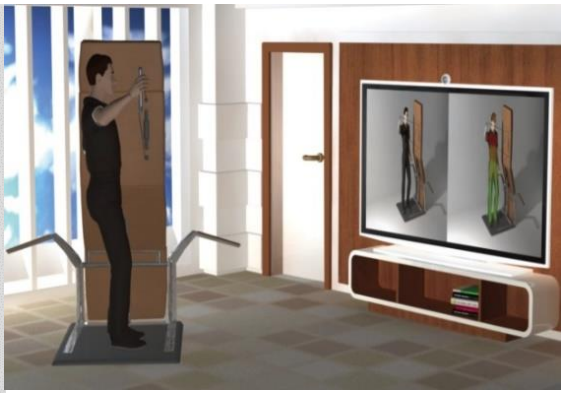
SOPHIA mit P.S

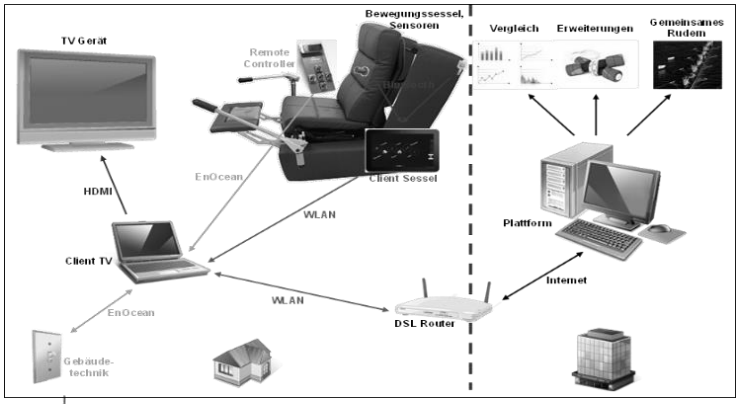
ISA

SPORTKREATIVWERKSTATT

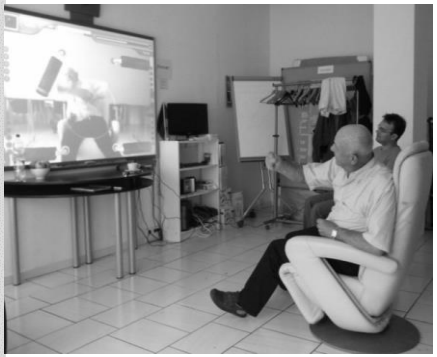
Fraunhofer
IIS

Technische Universität München





ECG
Oxygen saturation



Body weight

PASSAge: Personalized Mobility Assistance and Service Systems in an Ageing Society

SUNRISE MEDICAL

metaio

hmm

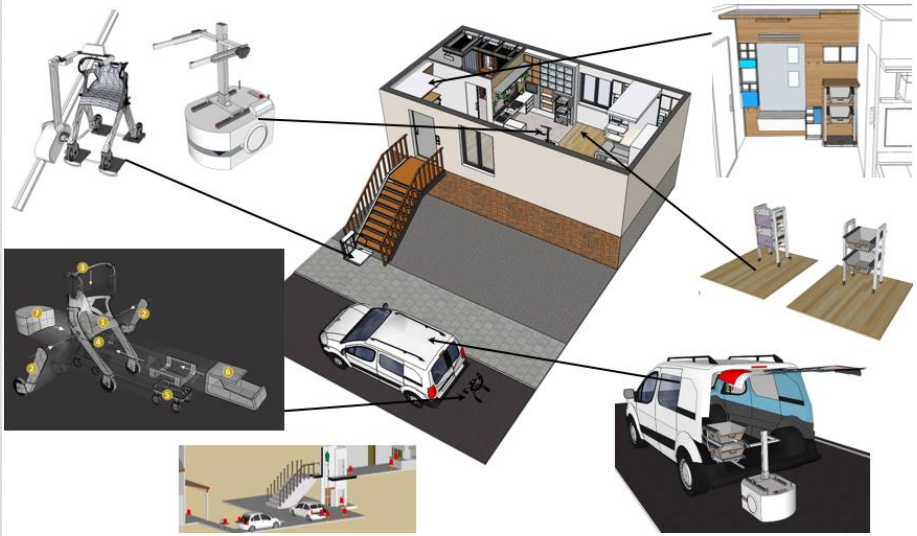
SOPHIA mit PS

HAAG REHATECHNIK

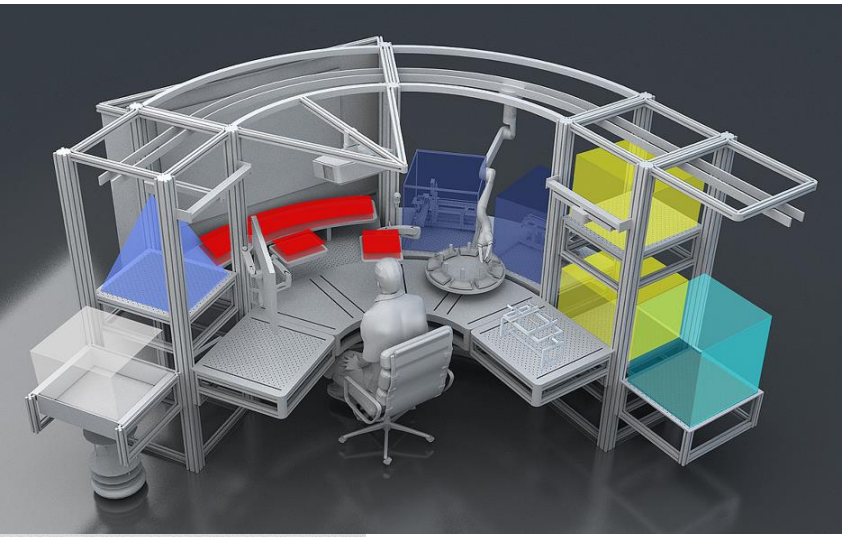
CITYSAX
DIE ZUKUNFT FÄHRT ELEKTRISCH!
WORAUF WARTEN SIE NOCH?

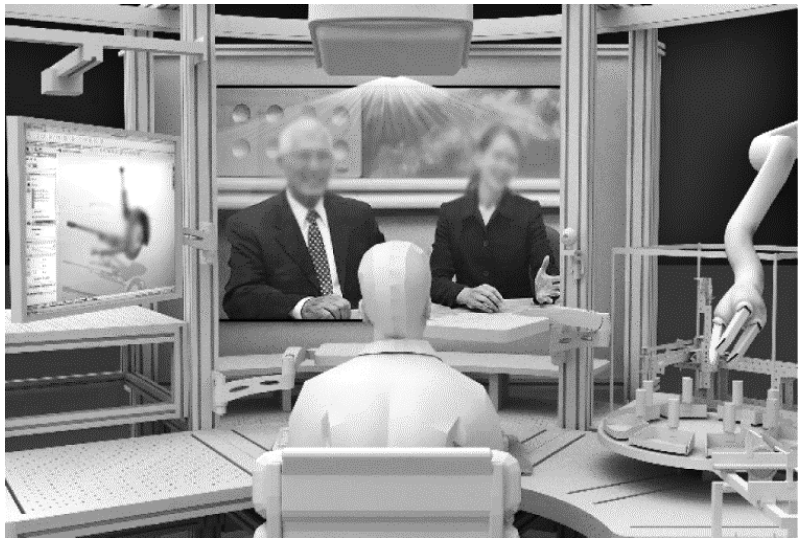
LMU Ludwig-Maximilians-Universität München

Technische Universität München



USA²: Robot Assisted Working & Cloud Manufacturing





(br)² MCTS

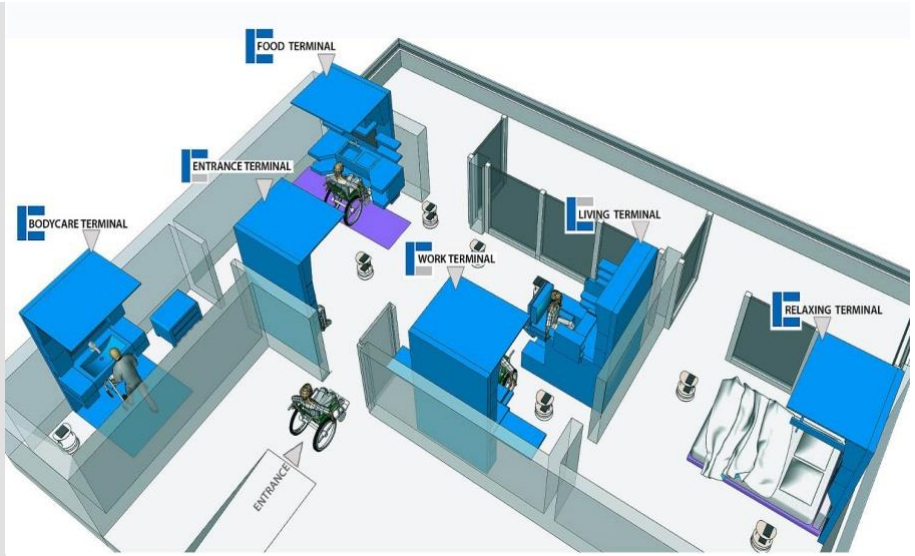
Technische Universität München

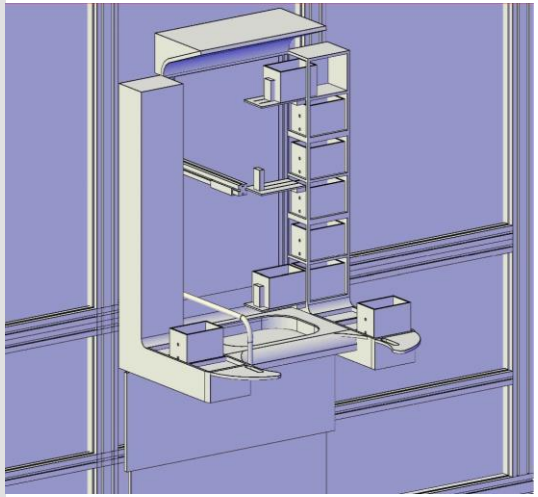
Utilization of Robotic Elements

Bundesministerium für Bildung und Forschung

Image: This work has been developed in the project USA² - the research project was finaced by the German Federal Ministry of Education and Research (BMBF, grant number: 16SV6191) within the Human-Technology Interaction (MTI) program/ technological development by Chair of Building Realisation and Robotics

LISA: Living independently in Südtirol Alto-Adige





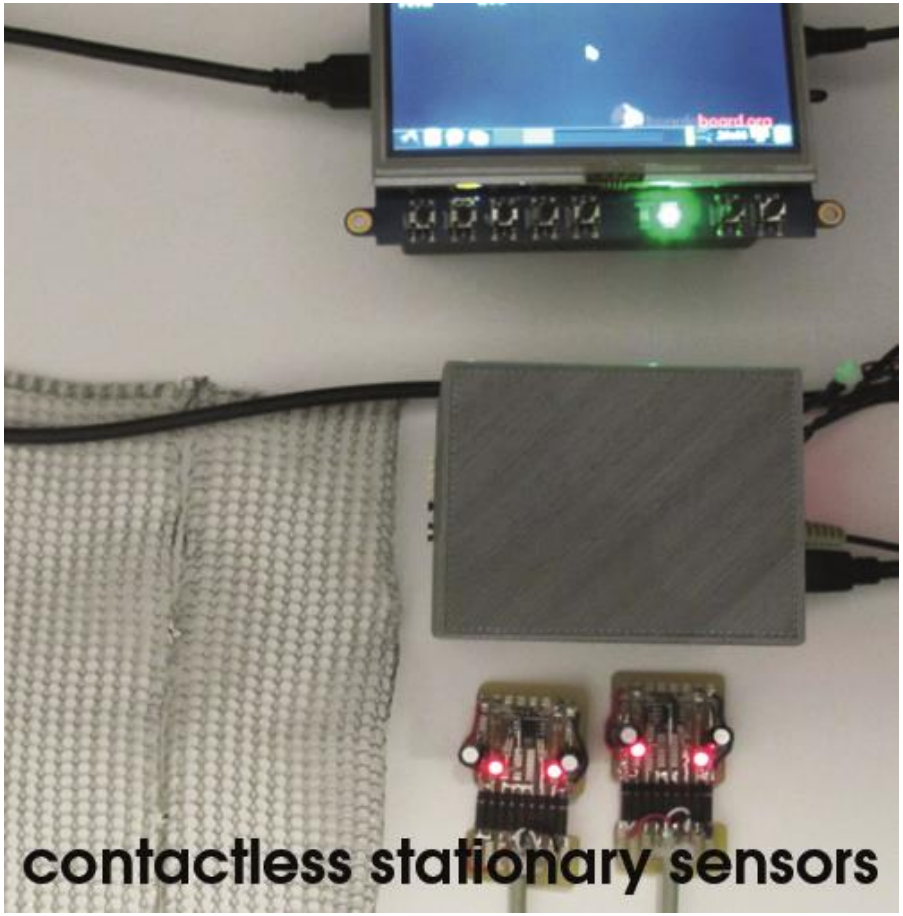
Rapid Installation / De-installation

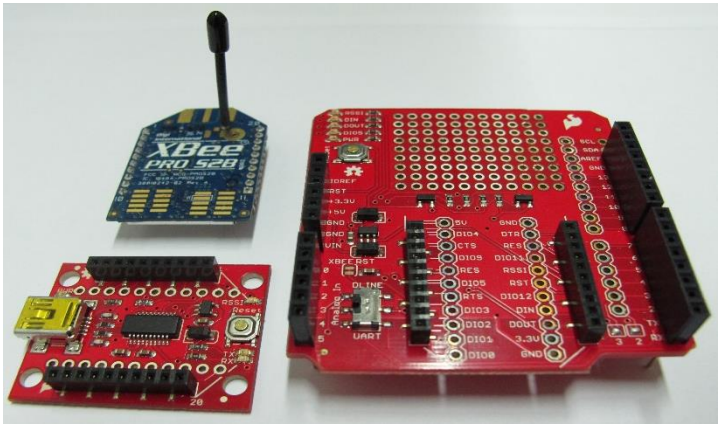
Rapid De-installation (TUM br2, Germany)

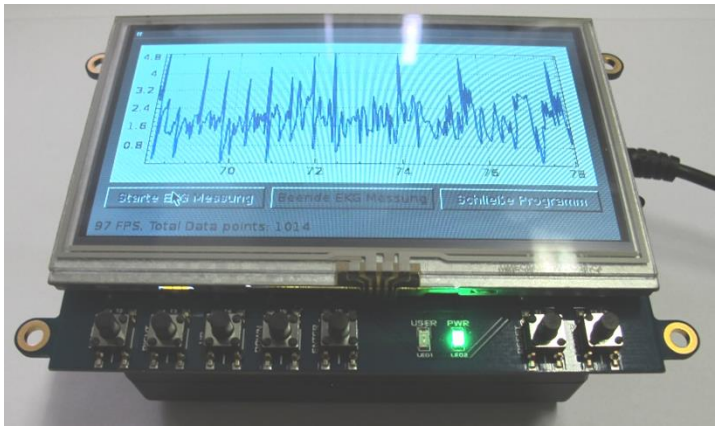
Rapid Installation (Bozen, Italy)

Images: LISA Industry Consortium & Chair of Building Realisation and Robotics

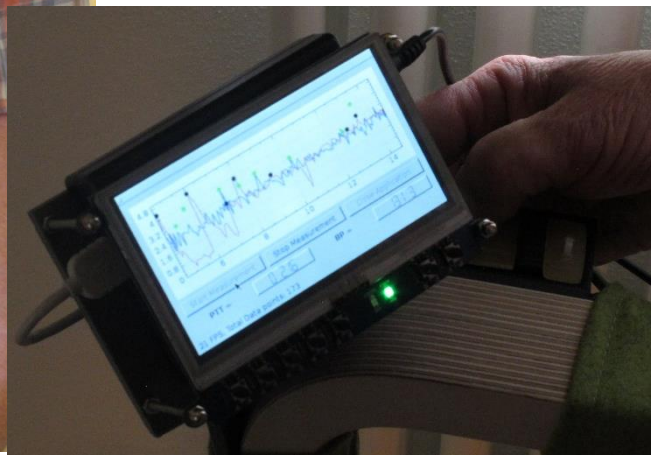
Contactless/Ambient Sensing



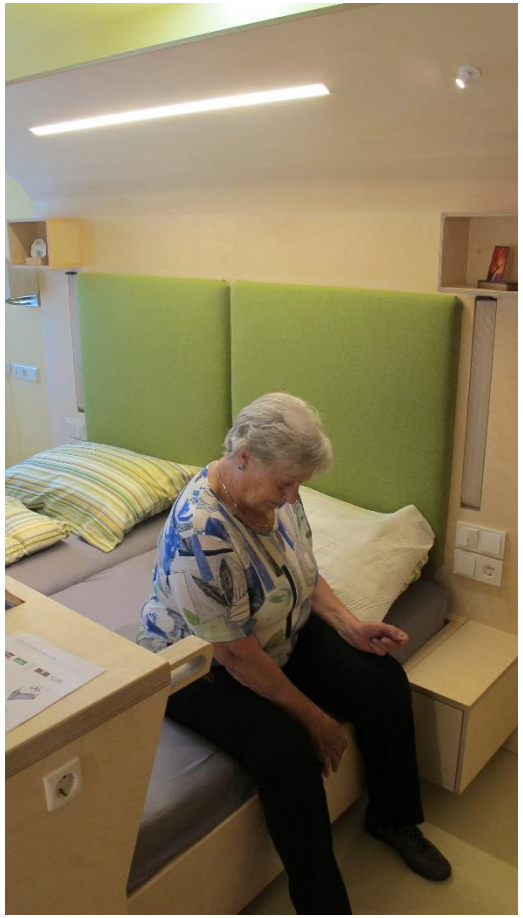




Contactless/Ambient Sensing



Contactless/Ambient Sensing



Contactless/Ambient Sensing

Contactless/Ambient Sensing

REACH (Responsive Engagement of the Elderly promoting Activity and Customized Healthcare)

Research:

Technische Universität München

Technical University of Denmark

Technische Universiteit Eindhoven University of Technology

École Polytechnique Fédérale de Lausanne

University of Copenhagen

Fraunhofer IAIS

Industry:

ARJOHUNTLEIGH GETINGE GROUP

ALREH MEDICAL

sturrm.

biozoon. food innovations gmbh

DIN

SmartCardia

PHILIPS

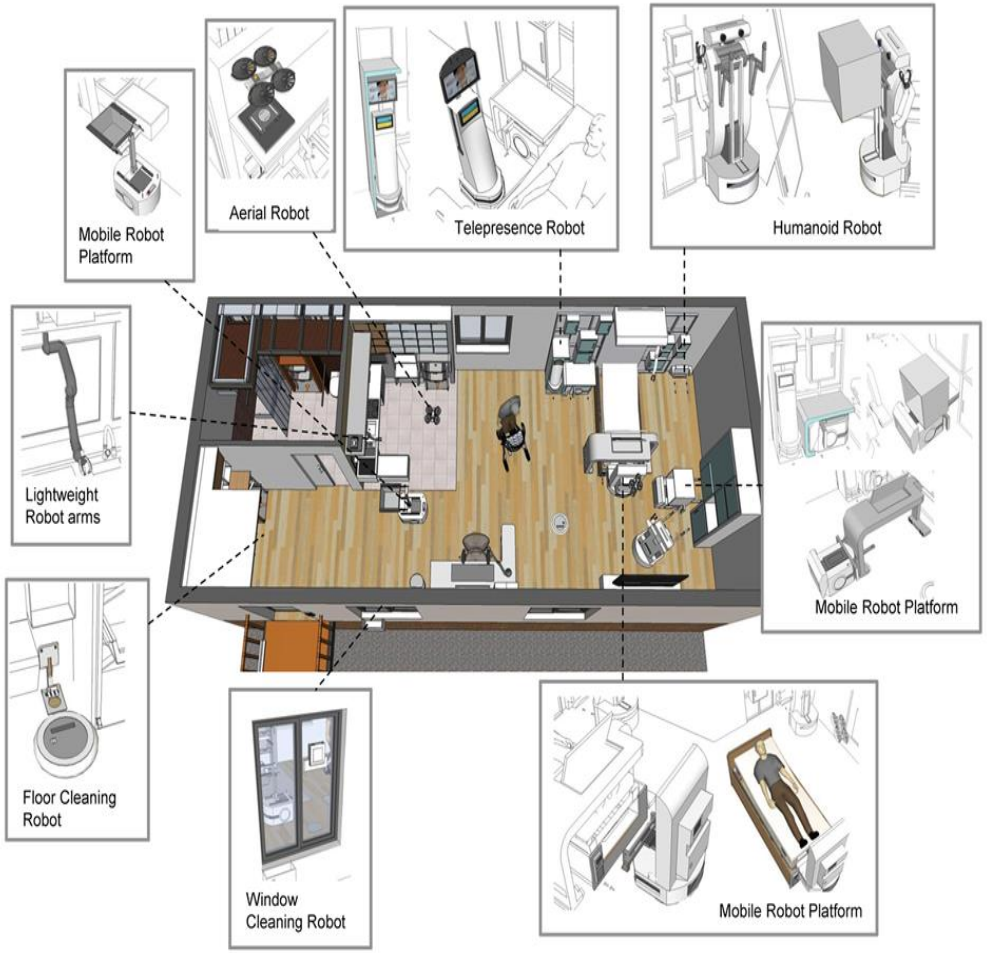
Application:

HUG Hôpitaux Universitaires Genève

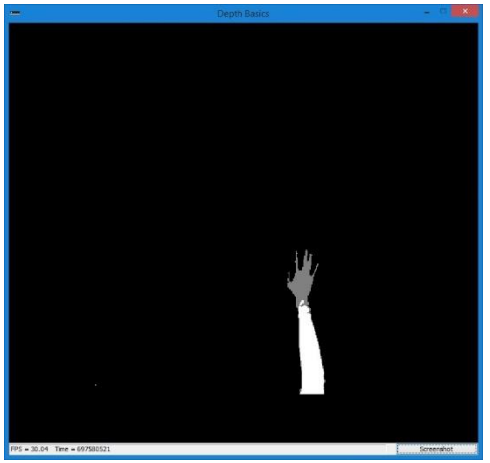
zuid zorg

SCHÖN KLINIK Bad Aibling

LYNGBY-TAARBÆK KOMMUNE

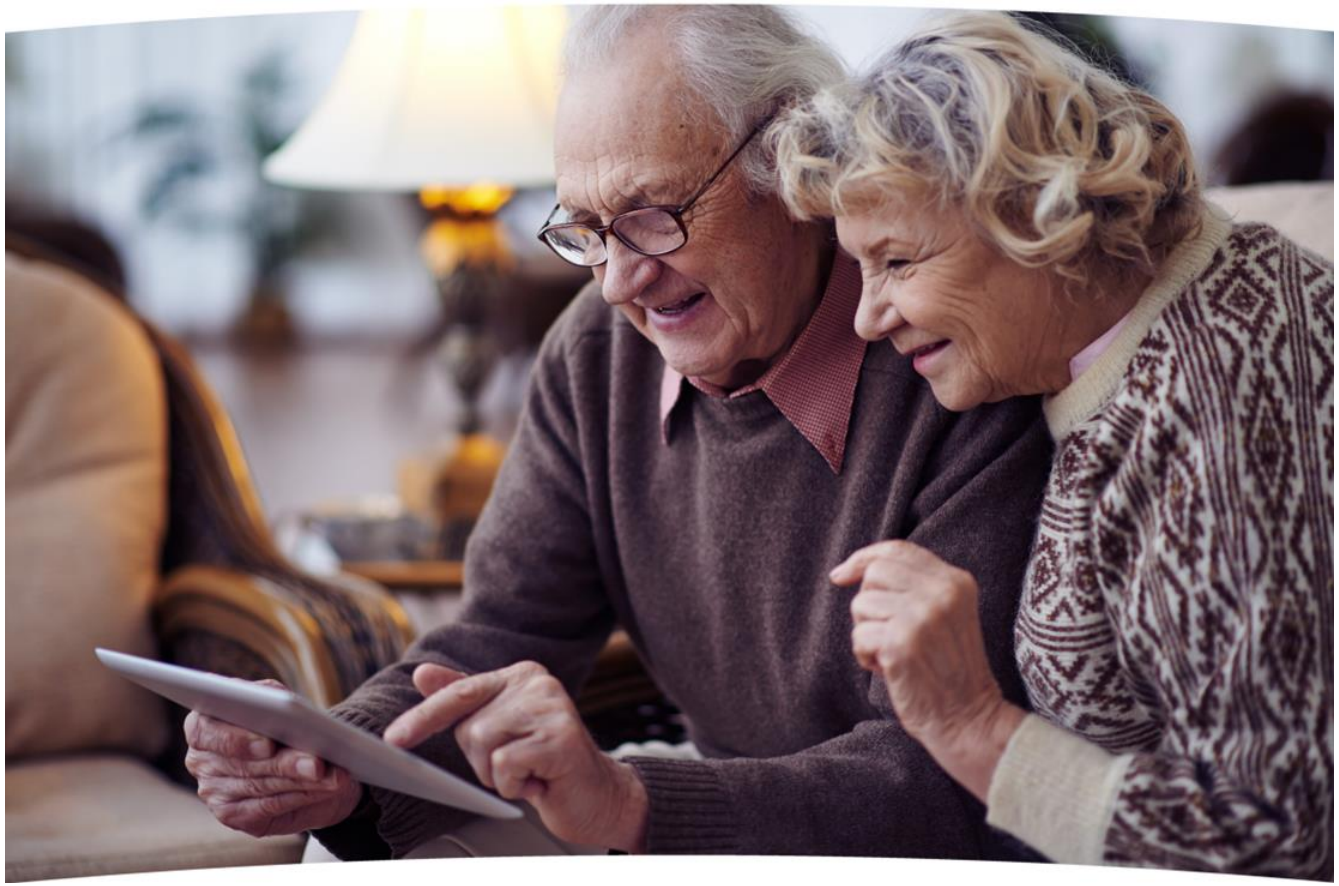


REACH – First Prototypes



REACH – First Prototypes

BaltSe@nioR

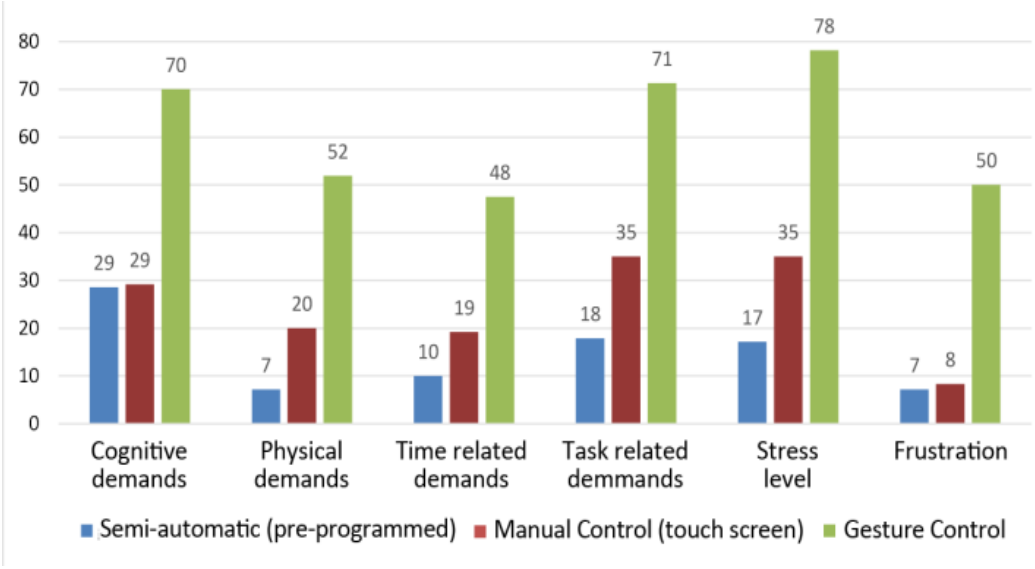


BaltSe@nioR – First Prototypes

User Integration and Usability

Evaluation collaborative work:

NASA TLX: average perceived task load levels (M) for test persons when operating the JRA in the collaborative assembly station by various, alternative control modes; N=21.



Control Mode 1: Semi-automatic

Control Mode 3: Gestures

Control Mode 2: Manual

Bundesministerium für Bildung und Forschung

Image: This work has been developed in the project USA² - the research project was finaced by the German Federal Ministry of Education and Research (BMBF, grant number: 16SV6191) within the Human-Technology Interaction (MTI) program/ Usability evaluation by br2 in cooperation with Berliner Institut für Sozialforschung (BIS)

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http://www.bertim.eu/ (website of the BERTIM project)

http://reach2020.eu/ (website of the REACH project)

http://baltsenior.up.poznan.pl/ (website of the BaltSe@nioR project)

http://www.cambridge.org/us/academic/collections/cambridge-handbooks-construction-robotics/titles (website of the Cambridge handbooks on construction robotics)